NBS Information Bulletin

NATIONAL BIOLOGICAL SERVICE
U.S. DEPARTMENT OF THE INTERIOR
No. 36 1995

Stocked Lake Trout Contribute to Population Recoveries in Lake Superior

Hatchery-reared lake trout (*Salvelinus namaycush*) are reproducing in Lake Superior and their progeny are contributing to the recovery of the lake trout population. Lake trout sustained an average annual yield of 2.0 million kg during 1913–50 in Lake Superior, but collapsed nearly to extinction during 1951–62 because of excessive fishing and predation by sea lamprey. Hatchery-reared juvenile lake trout were stocked, in conjunction with controls on sea lampreys and fishing, to restore lake trout populations. Stocking has been relatively continuous since 1951. Sea lampreys reached peak abundance during 1958–61, and have been reduced to 15% of that level since 1962 by chemical toxicants, barrier dams, and traps.

Hatchery Stocks Aid Population Recovery

The only study that quantified the contribution of stocked lake trout to recruitment in Lake Superior confirmed that stocked fish were reproductively ineffective compared with wild fish. A conventional view emerged that stocked lake trout were impaired in their ability to find suitable spawning grounds and spawned on sites that were inappropriate for incubation of fertilized eggs.

The contribution of stocked lake trout to recruitment has only been tested for a single spawning population in one area of Lake Superior. A similar analysis across more areas would determine the importance of different spawning habitat distributions (inshore, as in Michigan and Minnesota, versus offshore, as in Wisconsin) and of different densities of spawning stock (high, as in Michigan, versus low, as in Wisconsin and Minnesota). My objectives were to determine the importance of stocked lake trout, in comparison with wild lake trout, in population recoveries in different areas of Lake Superior. My null hypothesis was that stocked lake trout did not contribute to the recruitment of wild lake trout one generation later in that area.

Stock Assessment and Statistical Models Provide Answers

Trends in relative abundance of lake trout were monitored with standard gill-nets fished in each lake trout management area during 1959–93 in Michigan and Wisconsin and 1963–93 in Minnesota (Fig. 1). Hatchery-reared lake trout were marked by removal of a fin before stocking, so the catch per effort (CPE) of unclipped lake trout was assumed to be of wild fish and the CPE of clipped lake trout was assumed to be of stocked fish.

I used multiple linear regression to evaluate the relative contribution of stocked and wild lake trout to subsequent recruitment. I used the CPE of stocked and wild lake trout in spring assessment fisheries as indices of parental and recruited stock sizes and assumed that CPE of each parental stock would be related to CPE of wild recruits 8 years later if that parental stock was reproductively important. The model was:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \varepsilon$$

where

$y = \log_e$ catch per effort of wild recruits,
$x_1 = \log_e$ catch per effort of stocked parents,
$x_2 = \log_e$ catch per effort of wild parents,

and

ε = residual variance unexplained by the regression.

I evaluated standardized partial regression coefficients from the regression model to assess the relative importance of stocked and wild parental CPEs on recruit CPE in each management area. I used covariance analyses to determine if area-specific relations were homogeneous across management areas. The results of covariance analyses were used to consolidate homogeneous sets of management areas.

Offspring of Stocked Lake Trout Are Vital to Population Recovery

The CPEs of stocked and wild parents were correlated to the CPE of wild progeny 8 years later in all areas except MI8. Regression slopes for stocked parents were greater than for wild parents in all areas, and slopes for wild parents were not significantly different than zero in MI3, MN2, and WI2. Slopes were homogeneous among Michigan areas MI4 through MI7 for both wild and stocked parents, and there were no differences among areas. Slopes were also homogeneous among Minnesota areas MN2 and MN3 for both wild and stocked parents, but the mean for area MN2 was significantly lower than for area MN3.

Multiple coefficients of determination (R^2) for CPE of stocked and wild parents on CPE of recruits 8 years later ranged from 58% in MI6 to 95% in MI5 (Fig. 2). Most of the variation in CPE of recruits (67–79%) was explained by variation in CPE of stocked parents. Little of the variation in CPE of recruits (2–19%) was explained by variation in CPE of wild parents. In Michigan areas MI4 through MI7, the CPEs of stocked and wild lake trout explained 79% of the variation in CPE of progeny, of which 66% was explained by stocked parents and 9% was explained by wild parents. In Minnesota areas MN2 and MN3, the CPEs of stocked and wild lake trout explained 64% of the variation in CPE of progeny, of which 63% was explained by stocked parents and 14% was explained by wild parents.

Previous Assumptions

My results suggest that stocked lake trout were more important contributors than wild lake trout to the recruitment of progeny 8 years later in Minnesota and Michigan. Other investigators have concluded that stocked lake trout were reproductively ineffective in Lake Superior. This conclusion was subsequently held as the primary reason that lake trout restoration in the other Great Lakes had largely failed. However, previous stock-recruitment analyses in Lake Superior were restricted to the Apostle Islands area in Wisconsin, where spawning substrate is restricted to offshore shoals and islands that require a high degree of homing by spawning lake trout. In Minnesota, Michigan, and Ontario, however, spawning substrate is widely distributed inshore, where little homing is required by naive, stocked lake trout spawners. My results suggest that the distribution of spawning substrate in the Great Lakes is a critical determinant of successful reproduction by stocked lake trout.

Study Identifies Factors for Successful Stocking Program

My results suggest a successful stocking program is dependent on controlling total lake trout mortality and selecting stocking areas that provide suitable habitat for spawning, egg incubation, and nurseries. Unfortunately, lake trout restoration has been deferred in both northern Lake Huron and northern Lake Michigan where inshore spawning grounds are found. These areas have been reserved for maximum sustained harvest of lake whitefish, mostly by gillnets that impose high incidental mortality on lake trout. Spawning stocks have therefore not developed in the areas where inshore spawning grounds occur, and thus where the likelihood of successful reproduction is greatest. Rather, lake trout restoration has been pursued mostly in the southern portions of both Lakes Huron and Michigan, where inshore spawning grounds are largely absent. Only since the mid-1980's has lake trout restoration been moved offshore to the large offshore reefs of Lake Huron and Lake Michigan. Stocking in these areas, in conjunction with protection from fishery exploitation, should provide for successful stock restoration, as long as the fish remain in these areas to spawn.

Stock restoration in northern Lake Huron and northern Lake Michigan can only succeed if spawning grounds are still in suitable condition and if lake trout are afforded protection from fishery exploitation. Surveys of historic lake trout spawning grounds in northern Lake Huron and Lake Michigan have shown that substrate quality has not been observably degraded. Excessive fishery exploitation and sea lamprey predation probably explain the lack of successful reproduction by stocked lake trout in these areas. The success of future attempts to restore lake trout stocks depends on the extent to which fishery managers are able to control total annual mortality resulting from fishery exploitation and sea lamprey predation. Stocking of hatchery-reared fish continues to be a viable tool for lake trout restoration in both lakes, provided that these controls on mortality are effective.

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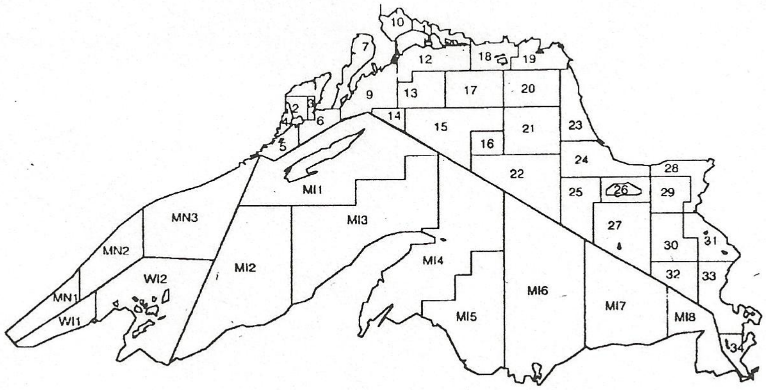

Fig. 1. Lake trout (*Salvelinus namaycush*) management areas in Lake Superior.

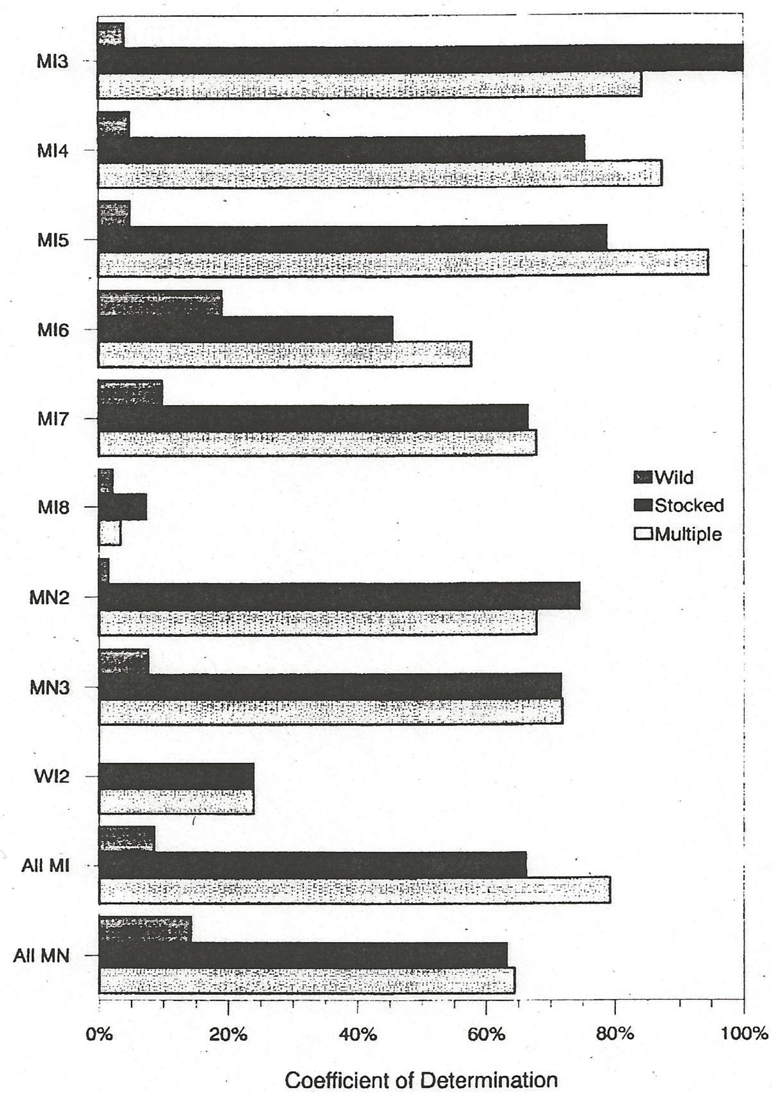

Fig. 2. Coefficients of determination of wild and stocked lake trout (*Salvelinus namaycush*) catches per effort (CPEs) on recruit CPEs in Michigan (MI3-MI8), Minnesota (MN2-MN3), and Wisconsin (WI2) waters of Lake Superior during 1950–1993.